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Optimizing Student Workforce Scheduling at PSU Office of Information Technology (OIT)

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Optimizing Student Workforce Scheduling at PSU Office of Information Technology (OIT)

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Abstract

A significant challenge for businesses of any size, is generating a work schedule that ensures adequate personnel coverage to ensure all aspects of the business are properly staffed, while preventing waste produced from having an excess number of employees working at a given time. The decision to manually create spreadsheets and work schedules that take into account availability, staffing requirements, and cost efficiency can become overwhelming and labor intensive. For Portland State University's Office of Information Technology (OIT), there is a significant challenge in scheduling student workers, while ensuring staffing requirements are met, student work hour restrictions are observed, and class schedules are accounted for. In order to better facilitate the scheduling and organization of work schedules for OIT, we have created a schedule optimization model, which will improve schedule generation efficiency, ensure staffing needs are met, allow for staff members to set their availability based on class schedules, and optimize the staffing costs of the OIT department. This model is intended to improve the flexibility, accuracy and efficiency in managing the OIT workforce and identify methods to reduce operating costs for the OIT department.

Executive Summary

Scheduling of staff and personnel is applicable in a wide variety of industries, such as medical personnel in hospitals, scheduling of airline and hotel personnel, and scheduling of IT staff are some of the common examples. The first part of this process involves determining the number of staff required, with the required skills, needed to meet the service demand. A good schedule balances the needs of employees, customers, and the employer. Some of the most common challenges with scheduling arise due to scheduling conflicts or poorly arranged schedules. This is usually caused by changes made to the schedule by different people, or lack of verification of the impact of the change on the rest of the schedule. Poorly arranged schedules include features such as lack of breaks, and limited employee coverage, resulting in business losses. This also leads to poor production due to low staff morale and overwork.

Effective staff scheduling consists of allocating the required workload to staff, subject to a number of constraints. The main objectives of staff scheduling are to efficiently utilize resources, produce a schedule with a balanced workload, and satisfy individual preferences as much as possible. There are various scheduling methods available, the chosen scheduling method should conform to the department workload pattern to enable creation of effective and efficient employee schedules. The one used for our model is a fixed, and team schedule method which is mainly used where the workload is predictable; that is, the work is consistent, does not require a lot of flexibility and also where the employees are scheduled as a group; that is, there is one schedule for a group of workers following the same pattern or completing the same tasks.

Literature Review

During the research phase of this project, many sources were reviewed to obtain relevant information that could contribute to the formulation and generation of a model for optimizing the scheduling process at OIT. Unlike examples of schedule optimizations utilized in construction projects, such as critical path method (CPM), where a combination of repetitive and nonrepetitive tasks need to be accounted for during the schedule optimization process, our model was focused on minimizing cost, while observing time constraints established by OIT existing scheduling rules. Most methods of schedule and cost optimization modeling involve a minimizing or maximizing objective that can be formulated mathematically by one or more linear objective functions.

Review of different methods for schedule generation commonly advocated the creation of a general formulation with-in the schedule, to allow for easier adaptation to specific problems. The advantage of such a general formulation is that it can be specialized and reduced for the solution of specific and, perhaps, less complicated scheduling problems.

Our process of developing the linear objective function for our model stemmed from resources provided by the OIT department, including copies of the current revision of the scheduling process. These manually generated schedules allowed us to identify staffing requirements for particular shifts and review employee availability records for schedule optimization purposes. We also reviewed the range of pay for different hourly employees, allowing us to create a range of hypothetically proposed pay levels for the employees that our model would be scheduling, allowing us to create a cost optimized objective function.

Current Application

The Office of Information Technology (OIT) employs about 150 employees, 120 are full-time, the remainder are student workers. There are 3 different departments these employees are assigned to: Front-end, back-end, and Lab Support. Each department has roughly 10 student employees and the staffing for each group is done separately. Currently, there is no plan to transfer the student employees from one department to another.

Our model is complementary to OIT current scheduling application. Our goal is not to replace the department's existing scheduling workbook. Our model reads the existing availability, it then uses that availability, to schedule employees based on cost. This will result in less weekly labor expenses incurred by the department.

We have two contacts from OIT, that we have been in contact with, and who we will be delivering the final model to. Jerrod Thomas is the Director of User Support Services, Sho Ikeda is the manager for the Helpdesk Department. We were able to obtain the department's scheduling workbook, this is what we have based our lp model and, not something that was made up. The workbook is very complex, scheduling is done on a term-by term basis, Monday-Sunday, from 9-7. Every shift is tracked down to 30 minute intervals. While our team has identified many short-falls of the departments existing application, our goal was not to replace this application, but accompany the solution, with the goal of minimizing weekly labor expenses for OIT.

Each department manages the scheduling manually, at the start of every term, each student fills out an availability form to indicate their availability. The manager of each department then creates the schedule, factoring in the student's availability.

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Decision Variables

The scheduling of student workers considers a time frame of one week. The independent variables in the LP model are the working position (i) and time slot (j). Furthermore, there are three different types of student workers: Lead, Coordinator, and Flex groups, and we handle these types of workers using the unique (i) value. We assign Lead to (i) = 1 through 3, Coordinator to (i) = 4 through 8, and Flex to (i) = 9 through 19.

The time slot (j) refers to the number of 30-minute blocks that each worker can work per day. We also have minimum workers required for each of the three groups above at time slot (j) and for each student worker, the availability is defined as 1 as available and 0 otherwise. Our model also optimizes the cost so we introduce a variable C_i as cost per hour for each worker

$X_{i,j}$ $\quad$ $Worker,\ working\ position\ (i)\ during\ time\ slot\ (j)$

$(Workers\ are\ subdivided\ into\ groups,\ which\ are\ broken\ into\ Lead,\ Coordinator\ and\ Flex\ groups).$

$i = 1, 2, 3\ \ Lead$

$i = 4, ...8\ \ Coordinator$

$i = 9, ...19\ Flex$

$j = time\ slot\ 8:30,\ 9:00,\ \ldots,\ 6:30$ Monday to Saturday

$R_{g,j}$ $\quad$ $Staffing\ required\ at\ group\ g\ in\ time\ slot\ (j)$

$g = 1, 2, 3$

$A_{i,j}$ $\quad$ $Availability,\quad (1)\rightarrow if\ available,\ \ (0)\rightarrow not\ available$

C_i $\quad$ $Cost\ per\ hour\ for\ worker\ (i)$

Objectives

The objective of the scheduling problem is to reduce the labor cost under the observance of various constraints.

$$min \sum_{j=1}^{108} \sum_{i=1}^{19} (X_{i,j} * C_i)$$

Constraints

1. The most important constraint is the minimum requirement required at each time slot for each group.

$$\sum_{i=1}^{3} X_{i,j} A_{i,j} \geq R_{1j} \quad \forall\ j\ \ [min\ Lead\ required]$$

$$\sum_{i=4}^{8} X_{i,j} A_{i,j} \geq R_{2j} \quad \forall\ j\ \ [min\ Coordinator\ required]$$

$$\sum_{i=9}^{19} X_{i,j} A_{i,j} \geq R_{3j} \quad \forall\ j\ \ [min\ Flex\ required]$$

The decision variable i.e. X i,j is multiplied with the availability variable and the sum of all these variables is compared with the minimum worker required for that group. This is done for every time slot.

2. The Lead and the Coordinator can only work 6 hours in a day. As the time slots are in slots of half hour the RHS is written as 12. The decision variable i.e. X i,j is multiplied with the availability variable and the sum of all these variables in each day is compared with the maximum time a worker can work in that day.

$$\sum_{j=1}^{20} X_{i,j}A_{i,j} \leq 12 \quad for\ i = 1,\ 2,\ \ldots 8 \quad [Monday\ work\ hours\ constraint]$$

$$\sum_{j=21}^{40} X_{i,j}A_{i,j} \leq 12 \quad for\ i = 1,\ 2,\ \ldots 8 \quad [Tuesday\ work\ hours\ constraint]$$

$$\sum_{j=41}^{60} X_{i,j}A_{i,j} \leq 12 \quad for\ i = 1,\ 2,\ \ldots 8 \quad [Wednesday\ work\ hours\ constraint]$$

$$\sum_{j=61}^{80} X_{i,j}A_{i,j} \leq 12 \quad for\ i = 1,\ 2,\ \ldots 8 \quad [Thursday\ work\ hours\ constraint]$$

$$\sum_{j=81}^{96} X_{i,j}A_{i,j} \leq 12 \quad for\ i = 1,\ 2,\ \ldots 8 \quad [Friday\ work\ hours\ constraint]$$

$$\sum_{j=97}^{108} X_{i,j}A_{i,j} \leq 12 \quad for\ i = 1,\ 2,\ \ldots 8 \quad [Saturday\ work\ hours\ constraint]$$

3. The last constraints are of non-negativity and binary. As a worker can only be working or not working we cannot have any non-negative values for X i,j. Also, X i,j must be binary. X i,j is 1 if worker i is working at time j and 0 otherwise.

$X_{i,j} \geq 0, \quad \forall\ i, j$ *[Non-negativity]*

$X_{i,j} \in$ *must be binary*, $\quad \forall\ i\ and\ j$

Analysis & Results

With the decision variables, objectives, and constraints explained above, an LP model was constructed. For cost and wage information, OIT could not give the numbers out, so we did our own research and came up with initial numbers that we could use as starting points for the inputs. These wage inputs were pulled directly from PSU, while we cannot know a specific workers pay, we can get accurate pay ranges, for different positions of student workers. This data allowed us to make very accurate assumptions, as to OIT hourly resource costs. We created a section in our workbook, that will allow any OIT scheduling manager, to input the hourly wages of all his staff.

The initial execution using Microsoft Excel reveals the limitation of Excel solver due to the complexity of the LP model with more variables(1000+) and constraints that Excel can handle. Faced with this situation, we turned our focus to open solver. Primary choice of open solver was based on the fact that for PSU OIT to execute the model, they don't have to purchase solver software with premium price.

After the model is executed with open solver, the weekly cost for Leads = $1355.50, the weekly cost for Coordinators = $813.38, the weekly cost for Flex = $3354.25. If we add all the weekly costs, it comes out to be $5523.13, as shown on the table below.

	Lead Workers	Coordinator Workers	Flex Workers	Total
Optimized Cost	$1,355.50	$ 813.38	$3,354.25	$5,523.13

Table 1. Optimized Cost Results

As mentioned earlier, the existing process from OIT is performed manually and does not take cost or wages into considerations. The help desk schedule manager manually performs the scheduling of student workers and they use higher-cost resource labors. We also mentioned that OIT did not give the wage information out and we used the numbers from our own research. For comparison purposes, we took the same numbers and we calculated the cost using the schedule that OIT completes manually.

For their schedule, the weekly cost for Leads = $1650, the weekly cost for Coordinators = $833, the weekly cost for Flex = $3456. If we add all the weekly costs, it comes out to be $5939 as shown on the table below. Comparing the total cost between OIT manual process and our LP model, the difference is $415.88 or **7% per week**. The significance of 7% per week reduction will be left up to OIT discretion, they could not share the wage information and our numbers are just starting points. OIT will react accordingly if they feel this reduction is significant enough. In addition, the LP model saves some manual work for help desk schedule manager by automating the scheduling process.

	Lead Workers	Coordinator Workers	Flex Workers	Total
Optimized Cost	$1,355.50	$ 813.38	$3,354.25	$5,523.13
OIT Manual Cost	$1,650.00	$ 833.00	$3,456.00	$5,939.00

Table 2. Cost Comparison between Optimized Cost and OIT Manual Cost

Limitations

Though this model gives an effective work schedule, and minimizes the cost required for the Office of Information Technology it also has its own limitations.

- OIT has a higher requirement of workers during the beginning of the term compared to the end. This variation cannot be reflected on the weekly schedule provided. For such requirements we might need another model which can be specifically used during peak times of each term.
- Since our model is optimizing the cost it usually selects an employee with less experience over a more experienced employee due to the difference in the wage. In an ideal work place more preference is given to the experienced.
- The solver might sometimes schedule an employee for only half an hour slot per day which is practically not suitable.
    - This can be solved with additional constraints, and employee availability. We recognize the fact that it's not practical, to schedule workers to come in for 30 minute shifts only. Ironically, there is instances in OIT existing scheduling application, where workers come in for only 30 minutes.
- If the availability of the workers is lower than the minimum requirement, the scheduling manager may be able to make a couple of calls to fill in the time slot. The person working may vary week to week. As Solver is inflexible, such a condition may just throw up an infeasible solution.

Future Work

While our model will optimize the cost, future research, and a thorough literature review, should be done, to understand the effects of scheduling models, that prioritize the cheapest labor available. While our model will cost PSU the cheapest amount of labor, there could be unintended side-effects on productivity when prioritizing cheaper labor. This in-turn, could affect the validity of our model, and require additional modifications, to make it production worthy.

Currently, we have a sheet in our workbook, that allows the manager to input employee wages, and student availability. Because our model uses binary for availability, the sheet is very large, and not great for user input. Functions could be added, to automatically update with the correct availability automatically, whenever the manager updates the scheduling workbook.

We developed our model around cost optimization, when scheduling hourly workers. If a business need were to arise, this model could possible be expanded to schedule a mix of salaried workers, and hourly workers, more representative of a true scheduling situation.

If this model proves to be effective for OIT, this model could be rolled out to other departments. Most any department would require minor, to significant changes, to tailor the model to the specific department. However, there is many areas where PSU staffs student workers, with complex scheduling requirements, these departments are perfectly suited to our model.

References

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